Mobile augmented reality game-based learning: teacher training using the EduPARK app

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DOI: http://dx.doi.org/10.25757/invep.v9i2.182

Abstract
With the mobile technology widespread, new functionalities are being integrated in devices, namely augmented reality (AR), which can be used to enhance learning. Combining mobile AR learning with game-based approaches supports new forms of instruction in the outdoors and students' engagement and motivation for learning are enhanced. However, new practices

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Pombo, L.., Marques, M., Carlos, V. (2019) Mobile augmented reality game-based learning: teacher training using the EduPARK app, *Da Investigação às Práticas*, 9(2), 3 -30.

DOI: http://dx.doi.org/10.25757/invep.v9i2.182

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(Recebido em novembro de 2018, aceite para publicação em março de 2019)

require teacher training. This is the case of the EduPARK workshop that aims to support teachers in the development of innovative outdoor practices, using mobile devices, AR and games. In this exploratory case study, qualitative and quantitative data were collected from five editions of the EduPARK workshop through a mandatory questionnaire and a voluntary reflexive self-account. Results show that teachers value this training for: the access to new educational resources; the practices changing support; knowledge update, although not necessarily in what concerns mobile learning, AR and game-based approaches; and learning about cross-subjects approaches to teaching.

Keywords: Teacher training, mobile learning, educational augmented reality, game-based learning, case study.

Aprendizagem móvel baseada em jogos de realidade aumentada: ensino de professores com a aplicação EduPARK

Resumo

Com a difusão das tecnologias móveis, os dispositivos começam a integrar novas funcionalidades, como a realidade aumentada (RA), que pode ser usada para potenciar a aprendizagem. Combinar a aprendizagem móvel com RA e abordagens baseadas em jogos sérios apoia novas formas de ensino ao ar livre e fomenta o envolvimento e a motivação dos alunos na aprendizagem. Contudo, novas práticas exigem formação de professores. Este é o caso do workshop EduPARK que visa apoiar professores no desenvolvimento de práticas inovadoras ao ar livre, usando dispositivos móveis, RA e jogos. Neste estudo de caso exploratório, foram recolhidos dados qualitativos e quantitativos de cinco edições do workshop EduPARK através de um questionário obrigatório e de um relato de experiência reflexivo e voluntário. Os resultados mostram que os professores valorizam esta formação para: aceder a novos recursos educativos; ter apoio na mudança de práticas; atualizar conhecimento, embora não necessariamente no que diz respeito à aprendizagem móvel, RA e abordagens baseadas no jogo; e aprender sobre abordagens interdisciplinares.

Palavras-chave: Formação de professores, aprendizagem móvel, realidade aumentada educacional, aprendizagem baseada no jogo, estudo de caso.

Apprentissage mobile basé sur les jeux de réalité augmentée: formation des enseignants à EduPARK app

Résumé

Avec la généralisation de la technologie mobile, nouvelles fonctionnalités sont intégrées dans des appareils, à savoir la réalité augmentée (RA), qui peuvent être utilisées pour améliorer l'apprentissage. La combinaison de l'apprentissage RA avec des approches basées sur le jeu prend en charge de nouvelles formes d'enseignement en plein air, ce qui renforce l'engagement et la motivation des élèves pour l'apprentissage. Cependant, les nouvelles pratiques nécessitent une formation des enseignants. C'est le cas de l'atelier EduPARK qui vise à aider les enseignants à développer des pratiques innovantes en plein air, avec des appareils mobiles, de RA et de le jeu. Dans cette étude de cas exploratoire, les données qualitatives et quantitatives provenant de cinq éditions de l'atelier EduPARK ont été collectées au moyen

d'un questionnaire obligatoire et d'un compte rendu volontaire et réflexif. Les résultats montrent que les enseignants apprécient cette formation pour: l'accès à nouvelles ressources pédagogiques; accompagnement pour l'évolution des pratiques ; mise à jour des connaissances, bien que pas nécessairement en ce qui concerne l'apprentissage mobile, les approches basées sur le RA et le jeu ; et l'apprentissage sur les approches interdisciplinaires.

Mots-clés: formation des enseignants, apprentissage mobile, réalité augmentée éducative, apprentissage basé sur le jeu, étude de cas.

Aprendizaje basado en juegos de realidad aumentada móvil: formación del profesorado utilizando *EDUPARK APP*

Abstracto

Con una amplia gama de tecnologías móviles, los dispositivos pueden integrar nuevas características como la realidad aumentada (AR) que se pueden utilizar para mejorar el aprendizaje. Combine el aprendizaje móvil con AR y enfoques de juegos serios que apoyen nuevas formas de aprendizaje al aire libre y fomenten el compromiso y la motivación de los estudiantes en el aprendizaje. Sin embargo, nuevas prácticas de formación docente. Este es el caso del taller EduPARK que tiene como objetivo ayudar a los maestros a desarrollar prácticas innovadoras al aire libre utilizando dispositivos móviles, RA y juegos. En este estudio de caso exploratorio, se recopilaron datos cualitativos y cuantitativos de cinco ediciones del taller EduPARK a través de un cuestionario obligatorio y un informe de experiencia reflexivo y voluntario. Los resultados mostrados por los docentes valoran esta capacitación para: acceder a los nuevos recursos educativos; tener apoyo en el cambio de prácticas; actualizar el conocimiento, aunque no se permite el acceso al aprendizaje móvil, AR y enfoques en el juego; y aprender acerca de enfoques interdisciplinarios

Palabras clave: formación docente, aprendizaje móvil, educación en realidad aumentada, aprendizaje basado en juegos, estudio de caso.

INTRODUCTION

New challenges to education are brought by empowering children and young people with digital media and connectivity, namely with mobile devices, arising the question if learners' expectations are changing, and if innovative pedagogies (novel or changing theories and practices of teaching, learning and assessment) for the modern, technology-enabled world are being met (Ferguson et al., 2017). However, there's no scientific evidence that students have dramatically changed their expectations about teaching, learning and technology, since despite valuing technology benefits, students still prefer traditional face-to-face teaching with the improvement of technology for higher engagement and more efficiency in learning tasks resolution and outcomes (OECD, 2012). If technology-based innovations are not clearly leading to learning improvements, reluctance and discomfort emerge in students but, on the other hand, 'the more rewarding experiences students get, the more likely they are to become supportive of technology-based innovations' (OECD, 2012, p. 113). Furthermore, studies clearly state that teachers will have to lead the process of integration of information and communication technologies (ICT) in schools (Montrieux, Vanderlinde, Courtois, Schellens, & De Marez, 2014; OECD, 2012). Hence, the literature acknowledges that ICT

integration in schools, with impact in teaching practices, requires teacher training (Horta, 2012).

As mobile technologies rapidly develop, the functionalities available on mobile devices grow in number and complexity which, along with the widespread availability and relatively low cost of mobile devices, constitutes an opportunity to leverage the power and ubiquity of mobile technologies to enhance learning and support professional training, continuing education and lifelong learning (Dykes & Knight, 2012). Furthermore, teachers need to be aware of both the advantages and constrains of mobile devices for teaching and learning (Passey & Zozimo, 2014).

Aiming to enhance instruction and encourage new pedagogical practices, when considering an approach to mobile learning, it is firstly vital to identify the central learning activities involved, and subsequently select the appropriate tools to support those activities (Dykes & Knight, 2012).

In what concerns mobile technologies, how it can support teachers and improve their practice, Dykes and Knight (2012) indicate that mobile technologies can improve professional development and teacher training in different domains, such as: communication (in conjunction with wireless broadband and video-call services, like Skype, to facilitate communication between teachers and mentors); self-assessment (video cameras to record lessons, allowing teachers to reflect on their teaching practice and identify areas for improvement); and innovation (in teacher education programmes to challenge teachers to think creatively about mobile learning and develop confidence in new practices).

Studies reveal evidences of a positive educational impact from using mobile technologies in education (Sung, Chang, & Liu, 2016), adding, however, that the positives outcomes depend on different variables, such as the promotion of teachers' empowerment, a strong technical team or even the implementation context (formal vs informal) (Haßler, Major, & Hennessy, 2016; Sung et al., 2016).

While looking at teacher responses to the implementation of mobile technology and how these affected the impact of technology use in the classroom, Montrieux and colleages (2014) found that teachers could be organised into two categories: instrumental teachers who believe tablets can offer benefits to teaching (for example relieving teachers of the need to print) but not changing their role as a teacher in any way; and innovative teachers, who believe tablets can offer changes by allowing them to deliver content in a different way, changing their role as a teacher and the relationships with their students.

Montrieux et. al (2014) also stress that deeper changes to teaching and learning require schools to offer continuous training on teaching methodologies that allow teachers to make the most of mobile technology. Sung, Chang, and Liu (2016) point that implementing effective mobile learning programs requires adequate preparation of the teachers, through professional development and highlight that teachers should be encouraged customise existing research-based mobile learning programs, minimizing the workload and time needed to innovate their practices.

Clarke and Svanaes (2015) identified Bring Your Own Device (BYOD), cloud computing, flipped classroom, games and gamification as digital strategies and technologies as the pedagogical trends for the next years. The same report (Clarke & Svanaes, 2015) also identifies as the most important challenges facing innovative use of ICT in education: integrating technology in teacher education, facilitating personalised learning and how to shift to deeper learning strategies. In the same line, Albion et al argue that teacher training must include learning with ICT to facilitate innovative pedagogical practices (Albion, Tondeur, Forkosh-Baruch, & Peeraer, 2015).

Prensky and Marc highlight motivation as the key of successful learning and yet argues that today's teachers, trainers and educators are not as effective as they should be in what concerns to motivation. Game play emerges as a contrasting reality since game designers are highly competent in promoting player engagement:

> the ability to keep people in their seats for hour after hour, day after day, at rapt attention, actively trying to reach new goals, shouting with glee at their successes, determined to overcome their failures, all the while begging for more (Prensky & Marc, 2003, p. 1)

As the author stresses, it makes sense to combine learning content and games motivation, since what attracts and glues kids to today's video and computer games, the learning the games provide (kids love to learn when it isn't forced upon them) (Prensky & Marc, 2003). Several types of learning emerge while playing games: game players learn to do things (fly airplanes, to drive fast cars, to be war fighters, civilization builders, …), to gather information from many sources and make decisions, to deduce game's rules from playing instead of being told, to create strategies for overcoming obstacles, to understand complex systems through experimentation, and to learn to collaborate with others (Prensky & Marc, 2003).

As Tobias, Fletcher, and Wind (2014) emphasise, there is a wide proliferation of terms in the literature related to different types of games ('serious games', 'educational games', 'fast action games', etc.). Considering the dimensions of game play - content of play, game context, game structure, and mechanics of game play, Kirkley, Tomblin, and Kirkley (2005) reinforce that integrating the motivating aspects of games with good instructional design is critical.

De Freitas (2006) points out that it is also important for the learning to be undertaken in relation to clear learning outcomes as well as being made relevant to real world contexts of practice, reinforcing that game play does not always involve sitting in front of a screen, due to new forms of games that include mobile and augmented reality gaming in outdoor contexts.

The author also stresses the need of more effective supporting materials for practitioners wishing to use game-based learning approaches, such as guidelines, case studies and practice exemplars (De Freitas, 2006). Furthermore, the potential for educators to contribute to the development of learning content associated with new games formats is substantial (De Freitas, 2006). Moreover, the author emphasises that the potential of game-based learning can only be supported by a coordinated approach to staff development and allowing tutors time to explore and experiment existing tools and game spaces (De Freitas, 2006).

By using immersive spaces and technologies such as virtual reality, 3D screens or handheld devices, learners can produce their materials, share learning experiences and rehearse skills for 'real-world' contexts in a classroom, at home, or in the outdoors (De Freitas, 2006; Ferguson et al., 2017). Since immersive learning can combine the use of advanced technology with active teaching methods such as role play and fieldwork, it can thus promote deeper engagement and participation (Ferguson et al., 2017). Technology available in smartphones can provide augmented reality (AR) or virtual reality (VR) learning experiences, allowing learners to see labels, images, 3D shapes, characters, or animations added to the view as part of a game, a puzzle, a trail, or other kind of environment exploration (Ferguson et al., 2017).

In summary, educational settings can benefit from both the use of technology to support innovative approaches to teaching & learning and from the motivational enhancement provided by educational games. However, to effectively promote mobile game-based learning, it is clear the need of continuous teacher training integrating new technologies (Clarke & Svanaes, 2015), about the use of mobile devices to enhance learning (Montrieux et al., 2014), allowing time to explore and experiment tools for game-based learning and prompting teachers to develop learning content (De Freitas, 2006). Moreover, the incorporation of AR into educational practices for an effective learning, instead of for merely beautiful scenographies, requires teacher training in teaching methodologies with AR technologies (Cabero & Barroso, 2016). Training opportunities that revolve around mobile game-based learning with AR are innovative and, therefore, it is important to analyse their potential for teachers' practice change, as it is the case of the EduPARK project, which will be presented in the following section. The remaining work is organised as follows: the 'materials and methods' section presents the adopted research methodology, an exploratory case study, the contexts of the analysed case, data collection and analysis techniques and the characterization of the participants in the study; then the 'results and discussion' section is organised according to the three objectives of this study; and, finally, the 'conclusions' section summarizes this study main findings, limitations and lines of future work.

THE EDUPARK PROJECT

Having as main challenge the creation of original, attractive and effective strategies for cross-subjects learning in Science, the EduPARK project (http://edupark.web.ua.pt) designed, implemented and evaluated an interactive application (app) for mobile devices, combining Augmented Reality (AR), game-based learning and Geocaching principles (hunting treasures/caches). The process of the app development is documented and can be consulted in previous studies (Pombo and Marques 2018a; Pombo and Marques 2017; Pombo and Marques, 2018b; Pombo, Marques, Lucas, et al. 2017; Afonso et al. 2017). This app was designed to enable teachers, students and the general public to explore and access cross-subjects information and multimedia contents within an urban green park located in Aveiro (Portugal), the 'Infante D. Pedro' Park, a park rich in botanical diversity and historical patrimony (Pombo, Marques, Loureiro, et al., 2017). Four learning guides for different target groups – 1st cycle of basic education; 2nd and 3rd cycles of basic education; secondary and higher education; and tourists – were developed. These guides integrate cross-subjects issues under the Portuguese National Education Curriculum, and present the players with questions and educational challenges, so that the park visitors can enjoy a healthy walk while learning. More information regarding the project can be found in (Pombo, 2018). The innovation of the

EduPARK project relies on the articulation of: the use of a new and easy to explore AR mobile app; geocaching-based learning in outdoor environments; and cross-subjects educational materials (the guides) (Pombo, Marques, Lucas, et al., 2017).

MATERIALS AND METHODS

The scarcity of teacher training on mobile game-based learning with AR makes it relevant to analyse their potential for teachers' practice change, starting with the perceptions of the involved stakeholders. In this line of thought, the present study focuses on a set of Portuguese teacher training workshops that aim to support teachers in the development of the skills needed to create and implement innovative outdoor practical activities, using mobile devices, AR and games, so that students can have an active role in their authentic learning process. Hence, this study fits the exploratory case study methodology (Yin, 2014) and conforms to the research question: 'What are the teachers' opinions on mobile game-based learning with augmented reality (AR) after teacher training?' More specifically, the objectives of this study are:

1. To assess teachers' self-reported training needs that prompt them to seek practice change through a workshop on mobile game-based learning and if those needs are perceived as met;

2. To elicit teachers' perceptions on the development of mobile learning strategies in their practice, after attending a teacher training on these issues;

3. To determine the usability of an app (the EduPARK app) that aims promoting approaches of mobile game-based learning with AR.

The context of the case

Five EduPARK teacher training 3h-workshops were conducted in the centre region of Portugal, involving a total of 69 teacher trainees. The first two workshops were integrated within the '1st Pedagogical Journey on Future Classroom Labs: new pedagogies and new technologies', that took place in May and June of 2017; the last three workshops were part of a 30h-teacher training course entitled 'Tablets in Education: development of digital competences under mobile learning methodologies', which included 15h face-to-face and 15h autonomous work and occurred in October 2017, January 2018 and May 2018. All these teacher training workshops were accredited, so that teachers could get credits for their career progress.

The EduPARK workshop intended to: contribute to enhance teachers competences in what concerns the design of alternative classroom models; change the usual practices integrating new methodologies, such as mobile learning, AR and games in outdoor learning contexts; disseminate an interactive educative mobile resource, the EduPARK App (freely available in the Google Play Store / http://edupark.web.ua.pt/app); and support teacher trainees in

reflecting upon the potential of using interactive mobile resources in their learning context. The workshop followed the following structure: to discuss about innovative educational environments and their associated methodologies; to present the EduPARK as an example of a research & development project based on games, outdoor learning and mobile AR technologies; to experiment in practice the open educational resource, the EduPARK App, which integrates different quizzes for different learning levels, as if teachers were students; to work in pairs to plan activities and to create educational resources that may be integrated in the educational app, to implement with students; and to evaluate the implemented activity and the workshop. The relevance of this workshop relies on:

a) a continuous teacher training that integrates new technologies, more specifically, mobile AR, as this was an identified need by Clarke and Svanaes (2015) and by Albion and colleagues (2015);

b) created opportunities for the proper pedagogical use and to support the integration of technology-based innovations in practices, as recommended by Cabero and Barroso (2016), Montrieux et al. (2014) and OECD (2012), particularly in what concerns to: why use these technologies?, what for?, and how to use them?;

c) specify to teachers a practice exemplar of a mobile AR game, offering them time to explore and to experiment an existing tool and game space, and prompts teachers to develop learning content for the presented tool, as indorsed by De Freitas (2006);

d) effectively contribute for teachers' attitude of change, concerning technological innovation and the confidence of using those technologies with their students.

Data collection and analysis

This research relies in multiple sources of evidence, as two data gathering instruments were used to triangulate quantitative and qualitative data: a mandatory workshop evaluation questionnaire; and a voluntary reflexive self-account.

The questionnaire is organised in three parts and includes a set of open and closed questions. The first part concerns the teacher training evaluation and integrates three questions about: the main reasons to enrol the workshop; its methodological aspects and organization; and comments & suggestions to improve the workshop in future editions. The second part is about the teachers' self-analysis of their use of mobile devices in educational contexts, particularly, how often they use them to promote student learning, as well as acknowledged advantages and disadvantages. Finally, the third part gathers teachers' opinions about the EduPARK App tested during the workshop. More specifically, this part integrates the System Usability Scale (SUS) (Brooke, 1996; Martins, Rosa, Queirós, Silva, & Rocha, 2015), as teachers' perceived mobile technology ease of use seems to be positively related to their intention of use in their teaching practice (Prieto, Migueláñez, & García-Peñalvo, 2015).

The questionnaire allowed also to collect teachers' basic demographic information, including gender, age, schooling, teacher experience, professional situation, and disciplinary group.

The questionnaire is online and was implemented at the end of each workshop in individual computers, and thus the response rates were 100% for all. The average response time was 10 minutes.

In addition to the questionnaire, a month after each workshop, the researchers sent to the trainees an email asking a voluntary reflexive self-account with two main dimensions: analysis of the workshop content; and the workshop importance for practical applications in a school context, namely in what concerns teaching, learning, and teaching & learning aspects. The request obtained 15 replies, from a total of 69 teachers; hence, the response rate for this instrument was 21.7%.

At last, quantitative data analysis includes descriptive statistics and the SUS computing, according to Brooke (1996). Qualitative data were submitted to content analysis with empirically emergent categories (Wallen & Fraenkel, 2013). In the following section, the main results of this study will be presented and discussed.

Characterization of participants

Table 1 summarises the trainee teachers profile regarding their demographic and professional data, per EduPARK workshop and in total. The majority of the trainees was female (57 trainees in a total of 69), with an average age of 50. With many years of teaching experience (53 teachers with 21 or more years of experience), all respondents possessed a high degree course (44 teachers) or higher (25), as required by the Portuguese legal regulations about teachers' recruitment. Regarding professional status, most trainees (57) were school allocated teachers; hence, with a high professional stability. The higher diversity was found in the teachers' recruitment subject groups, as they belong to 16 different groups, all from non-Higher Education contexts. Many teachers belong to natural sciences subject groups (12 respondents from '520 group' and 10 from '230 group') or other Science, Technology, Engineering, and Mathematics (STEM) subjects (6 from subject '500 group' and 5 from each of the subject '510 and 550 groups'), and 11 teachers worked with students with special needs.

Table 1. Questionnaire respondents' profile, discriminating demographic and professional information according to the workshop attended

		Workshop					Total
		I	II	III	IV	V	
N. of trainees		16	14	12	14	13	69
Gender	Female	11	14	11	11	10	57
	Male	5	0	1	3	3	12
Average age (years)		47.8	52.6	52.1	48.8	49.7	50.1
Teacher experience (years)	<5	0	0	0	0	0	0
	5-10	1	0	0	0	1	2
	11-15	2	0	0	2	1	5

			Workshop					Total
			I	II	III	IV	V	
	16-20		3	1	1	4	0	9
	21-25		3	3	3	4	4	17
	26-30		5	7	3	0	3	18
	>30		2	3	5	4	4	18
Schooling	High Degree		12	12	5	8	7	44
	Post-graduation		1	1	3	3	2	10
	Master degree		3	1	4	3	3	14
	PhD		0	0	0	0	1	1
Professional status	Contracted teacher		3	0	0	0	0	3
	Zone allocated teacher		0	0	1	5	3	9
	School allocated teacher		13	14	11	9	10	57
Recruitment subject group	Groups	Education Level						
	110: Primary instruction	1.º CBE	0	0	1	1	0	2
	220: Portuguese/ English	2.º CBE	0	0	1	0	1	2
	230: Mathematics /Natural Sciences		5	5	0	0	0	10
	240: Visual and Technological Education		0	0	0	2	0	2
	260: Physical Education		0	0	0	0	1	1
	300: Portuguese	3.º CBE and Secondary	0	0	1	1	2	4
	330: English		0	0	0	0	1	1
	400: History		0	0	1	2	1	4
	420: Geography		0	0	0	0	1	1
	500: Mathematics		1	2	1	2	0	6
	510: Physics/ Chemistry		3	1	1	0	0	5
	520: Biology/ Geology		3	6	2	1	0	12
	550: Information and Communication Sciences		4	0	0	1	0	5
	600: Visual Arts		0	0	0	0	1	1
	910: Special Needs	All levels	0	0	4	4	4	11

			Workshop					Total
			I	II	III	IV	V	
	M17: Piano	Vocational Teaching	0	0	0	0	1	1

The teacher cohorts, who attended the workshops, reflect the demographics of the profession in the Portuguese context. More specifically, and according to DGEEC and DSEE (2017), in the 2015/2016 school year, the majority of teachers of non-Higher Education was female (71.7% or above in all school levels, according to 'Gráfico B.II.1' from DGEEC and DSEE, 2017, p. 45), with an average age of 45 or above (in all school levels, according to 'Gráfico B.I.2' from DGEEC and DSEE, 2017, p. 32). Moreover, 81.1% (or more, in all school levels) of teachers have a high degree (according to 'Gráfico B.III.1' from DGEEC and DSEE, 2017, p. 53) and are school or zone allocated (according to 'Gráfico B.VII.1' from DGEEC and DSEE, 2017, p. 85).

RESULTS AND DISCUSSION

As mentioned before, this study aims to reach teachers' opinions on mobile game-based learning with AR, after the EduPARK workshop, which was developed to support teachers in the development of ICT skills for technology integration in their practices. The data collected in this case study is now organized accordingly to the three research objectives, stated at the previous section.

Objective 1 – teachers self-reported training needs

Teachers expressed their reasons for enrolling in teacher training, as illustrated in the Figure 1. Teachers were asked to select all the reasons why led them to enrol in the EduPARK workshop, with a total of 229 reasons (about 3.3 reasons per teacher). The three main pointed out reasons are: getting access to new resources (47 teachers); change in the teaching practice (45 teachers); and knowledge update (34 teachers). Teachers' will of getting access to new resources, namely for game-based learning approaches, has been already pointed in the literature (De Freitas, 2006; Pombo, Carlos, & Loureiro, 2017). Our results empirically support this claim.

Surprisingly, in a certified short course, getting a certificate (motive selected by only 5 teachers) seemed to be the less relevant reason for attendance. Additionally, the topics of the workshop (mobile learning, augmented reality and Geocaching in Education) reached a moderated to low importance, with a total of 45 teachers referring them.

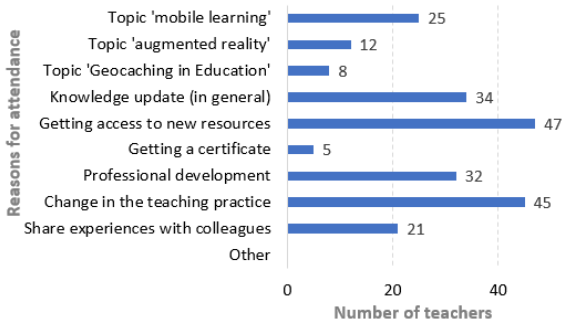

Figure 1. Teachers reasons for course enrolment – graphic of frequency (several option selections were allowed)

In light of the presented results, the cohorts of teachers of the EduPARK workshop expressed that their training needs include: getting access to new educational resources; having support in changing their teaching practices; and updating their professional knowledge, although not necessarily in what concerns mobile learning, AR and game-based approaches. Hence, teachers seem to be willing to learn more about effective ways of teaching, in order to change/improve their teaching practices and through new/innovative resources use. This was also observed in Pombo, Carlos, and Loureiro (2017), also a study that reports the support strategies used to evaluate the teacher practices at the end of a teacher training course, which found that the available technologies, when optimised and accompanied by suitable teaching formats, can be very valuable in the teaching and learning process, enhancing the classes dynamics, effectiveness and motivation, contributing to an active and significant learning.

The relevance of the provision of adequate teaching material for mobile devices has been previously pointed by Montrieux et al. (2015), who also mentioned that teachers should not feel pressured into adopting the role of academic author due to the increased workload.

In spite of most teachers from these workshop cohorts having 20 or more years of teaching experience, it is noteworthy that they are still interested in new educational resources and in changing their practices, at least at the level of the discourse.

In what concerns teachers' evaluation of the EduPARK workshop, Figure 2 shows it is very positive. They highlighted that the workshop methodology is suitable (62% strongly agreed and 35% agreed), its resources are interesting (67% strongly disagreed with the negative statement and 17% disagreed), with not too hard activities (48% strongly disagreed with 'the workshop activities were too hard' and 25% disagreed). Teachers expressed satisfaction with having attending the workshop (62% strongly agreed and 29% agreed), and that they would recommend the workshop to colleagues (54% strongly agreed and 38% agreed). Moreover, teachers referred feeling more prepared to use mobile devices in teaching (33% strongly agreed and 41% agreed), which indicates, in line with Dykes and Knight (2012), that this workshop challenged teachers to develop confidence in this new practice, therefore it contributed to meet their training needs, at least in some degree.

Teachers were asked to present a comment or improvement suggestion for the workshop in the questionnaire. They presented 42 general comments and improvement suggestions for the workshop, as revealed by the Table 2, 32 teachers either did not answer this question or presented a 'No comments' answer. Additionally, about one month after the teacher training, 15 teachers presented 64 comments regarding the workshop and its impact on their practices. It is worth mentioning that, not surprisingly, teachers' comments in the reflexive self-account were more fruitful, as they were able to take the time they needed to voluntary explain their thoughts regarding the requested topics.

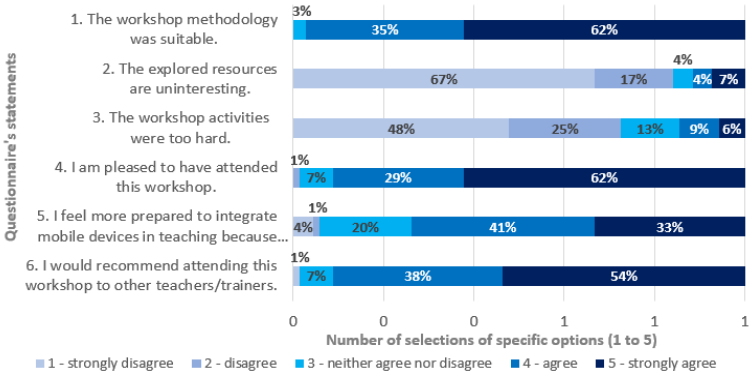

Figure 2. Teachers evaluation of the workshop (percentage of agreement with the questionnaire statement)

Table 2. Teachers evaluation on the EduPARK workshop in the questionnaires

Category	Sub-category	Analysis dimension	Citations examples	Frequency
General comments	Workshop quality	Adequacy of the workshop	'Brief and objective exploration of the theme' Q8 'in a timely manner' Q8 'Good trainer communication to the trainees.' Q56	4
		Increased teacher motivation	'It created interest for the search of similar situations.' Q5 'I'm enjoying and eager to know more applications.' Q44	2
		Learning promotion	'Fantastic! I have learned a lot.' Q23	1
Improvement suggestions	Teaching methodologies	Provide more specific support on teaching methodologies	'Being more specific according to each subject group.' Q6 'I believe it is important … to give examples of planning / implementation of lessons using	6

Category	Sub-category	Analysis dimension	Citations examples	Frequency
			this type of resources.' Q40	
		Include more practical work	'To have more practical activities.' Q17	1
		Include more expositive work	'To show the diverse app functions to the group, so that it is easier to explore by all the trainees.' Q51	1
		Increase interaction among trainees	'more interaction among trainees' Q56	1
	Organizational issues	Allow more time for the workshop	'To have more time to explore the app.' Q7	14
		Have the workshop in other locations	'To do the workshop in the park.' Q35 'To do the workshop in the other schools.' 32	6
		To review the workshop timing	'The timetable of the workshop should be different' Q61 'It should not be more than 15 hours' Q66	2
		Provide technical support	'To have more than one trainer for technical support.' Q36 'The computers should be previously tested' Q9	2
	Content related issues	EduPARK app related	'To disseminate this content to teachers' Q63 'To apply this type of app to different places of the city (e.g., the Museum)' Q69	2
			Total	42
			No comments 'Nothing to point out.' Q1	19
			No response -	12

Note: The notations 'Q' followed by a number indicate the questionnaire from which the citation example was taken

In the 'general comments' category emerged only one sub-category related to the workshop quality. This included three dimensions of analysis: adequacy of the workshop (4 mentions), increased teacher motivation (2 mentions) and learning promotion (1 mention). Hence, teachers who have expressed their opinion of the workshop quality considered it was high. The authors of this work claim that this result can be extrapolated for the rest of the workshop cohorts, bearing in mind the rest of the questionnaire results. As teachers had already agreed with statements as 'The workshop methodology was suitable' and 'I feel more prepared to integrate mobile devices in teaching because of this workshop' they may not feel the need to reinforce this idea in the open question about the workshop.

Teachers' evaluation of the workshop was positive; nevertheless, they were able to propose some improvement suggestions. Three sub-categories emerged in the 'improvement suggestions' category: 'teaching methodologies', 'organizational issues' and 'content related issues'. The 'teaching methodologies' sub-category had little expression, with only 9 mentions. Within this sub-category, 6 teachers mentioned 'provide more specific support on teaching methodologies' and 3 pointed other aspects. The 'organizational issues' were more frequently expressed (by 24 teachers), particularly to 'allow more time for the workshop' (14 teachers mentioned this) and to 'have the workshop in other locations' (6 teachers), especially in the park. 'Content related issues' were also present in the minds of a minority of these teachers' cohorts (2 teachers).

These results point that to meet further teachers training needs, it will be important in future editions of the EduPARK workshop to allow teachers sufficient time to properly explore the mobile AR game-based learning resource. This indicates that teachers seem to require time to explore new and innovative resources and, ultimately, change their teaching practices. This result is coherent with the literature, as for example Montrieux and colleagues (2015) found that teachers need sufficient time in their professional development to become familiar with mobile devices, in order to develop the required competences to employ these new technologies in their practices in an innovative way. Or the example in Pombo, Carlos, and Loureiro (2017), stating that the use of technology, when used adequately and associated to strategies to meet the aims of the lessons plans, has a positive impact on the educational process. However, it is a process that requires time of maturation, because although teachers are apparently very motivated, there is still some resistance to the use of technology when it implies extra time to prepare the classes.

Nevertheless, it is possible that the need to explore more the technology is more relevant for older teachers, as younger teachers may feel more at ease with mobile AR technologies. This idea needs further research, with a more diverse set of teacher cohorts.

A month after each workshop, a subset of teachers (15 out of 69) produced a reflective analysis of the workshop and its importance for practical applications in a school context (Table 3). The emergent categories were: workshop features; workshop content; impact in trainees; and impact in students. Under the workshop features, the trainer quality (mentioned by 3 teachers) and the training methodologies (7 teachers) were highlighted. Teachers appreciated the authentic learning approach (2 teachers), the collaborative work opportunity created (2 teachers) and the practical work of planning a mobile AR game approach in their subject area (3 teachers).

Table 3. Teachers evaluation on the EduPARK workshop in the reflexive self-accounts

Category	Sub-category	Analysis dimension	Citations examples	Frequency
Worksop features	Trainer quality	Dynamic	'I found the trainer superb, motivating, and able to quickly solve the technical problems.' M2	3
	Training methodologies	Authentic learning	'To explore the project app in real context … which is not usual in the training we usually attend.' M13 'the use of the app in an outdoor setting'; 'You learn in a funny way … it was what I felt when I explored the app, assuming the role of student' M17	2
		Collaborative work	'The exchange of experiences during the workshop was a true enrichment for me, as collaborative learning creates potentially more gains than the individual learning.' M10	2
		Practical work	'The workshop promoted practical activities' M10 'I still had the opportunity to create questions for the mobile app, within the scope of my subject area.' M14	3
Workshop content	Teaching strategies	Cross-subjects	'This methodology will be excellent for conducting cross-subjects activities, mobilizing multiple areas of knowledge.' M1 'I learnt it is possible to cover a series of contents of different subjects, not only natural sciences, with that application, appealing to an authentic cross-subjects approach.' M2	5
		AR use	'The augmented reality is a technology in great development and with great potentiality in pedagogical practices.' M5	4
		Game approach	'The possibility of creating an extremely attractive strategy for our students … because of the game nature and the competitiveness' M6	3
		In the outdoors	'Nowadays, outdoor settings seem to be a strategy with high success' M15	3
		Collaborative work	'The possibility of creating an extremely attractive strategy for our students … because it allows students to work in groups' M6	3

Category	Sub-category	Analysis dimension	Citations examples	Frequency
		Interactivity	'This technology allows to assist the teaching and learning process providing more interactive and dynamic learning at distance' M8	1
	Access to resources	Resources for teaching practices	'the application allows access to learning objects' M12 'I could learn about new digital tools, until that moment, unknown.' M1 'The possibility of try out new tools.' M6	5
Impact in trainees	Teacher motivation	Motivation for outdoor learning	'I feel especially motivated to organise with my colleagues a peddy paper using the presented tool.' M1 'I booked a meeting with my subject group delegate to propose a field trip to the park.' M6	4
	Teacher competence	Use of mobile AR technology and game approach in Education	'The use of this application involves a complexity, obliging the mobilization of multidisciplinary knowledge, so that teachers can be able to integrate those pedagogical and technological variables.' M3	2
	Practice change	Strategies innovation	'The possibility of creating an extremely attractive strategy for our students … because it is an outdoor activity in contrast to old classroom strategies.' M6	5
		Technology integration	'The training is essential I order to promote the integration of this knew pedagogies in the teaching and learning process.' M3 'The only obstacle to use these tools will be the curriculum compliance' M15	2
		Support in learning monitoring	'The app can also help to detect students learning difficulties at a level of logical reasoning and the organisation of thinking' M12	1
Impact in students	Student motivation	Motivation for learning	'These new technologies and new pedagogies can create new learning environments, which are more motivating, pleasant and effective, so that students become thinkers.' M3 'I saw it was a quite motivator tool.' M4	5

Category	Sub-category	Analysis dimension	Citations examples	Frequency
	Student engagement	Engagement in learning	'The use of this app allows teachers to raise the students' attention inside and outside the classroom.' M4	3
	Learning	Active learning	'The app helps the students to learn by themselves, as a way of active learning without limiting autonomy or creativity' M12	2
		Authentic learning	'Learning by doing is more effective encouraging the acquisition of content.' M7	2
		Competences development	'The app allows the development of essential competencies' M12 'This tool promotes the development of critical thinking …' M15	2
		Complement to traditional learning	'It constitutes a great complement to other type of learning' M9	2

Note: The notations 'M' followed by a number indicate the reflexive self-account from which the citation example was taken

Regarding the workshop content the teaching strategies were the most frequent sub-category, with: cross-subjects (5 mentions); AR use (4 mentions); game approach (3 mentions); in the outdoors (3 mentions); collaborative work (3 mentions); and interactivity (1 mention), in a total of 19 mentions. The access to resources, for teaching practices, was also valued by 5 teachers.

In what concerns impact in teacher trainees, the respondents referred: teacher increased motivation, particularly for outdoor learning (4 mentions); teacher competence development, in the use of mobile AR technology and game approach in Education (2 mentions); and practice change through strategies innovation (5 mentions), technology integration (2 mentions) and support in student learning monitoring (1 mention). This category included 14 items.

Finally, in the category of impact in students, the most mentioned one was student motivation (5). Other acknowledged impacts were student engagement (3 mentions) and learning, particularly, through active learning, authentic learning, competences development and complement to traditional learning, with 2 mentions each. This category was cited by a total of 16 teachers.

From the above results, the workshop content was the most frequently mentioned issue, particularly using cross-subjects as a teaching strategy and the access to new resources. Surprisingly enough, teachers did not seem to value as much the potentialities of the mobile AR technology the workshop intended to introduce. Nevertheless, according to the responses of the questionnaires, teachers seemed to value in similar ways the workshop impact into teacher trainees and into students, not mainly in students. This difference may be

due to the time frame that separates the data collection with the questionnaires and the reflexive self-account; indicating that time to reflect on the workshop may increase teachers' awareness of the training impact in their own practices. However, this is an issue than need further study.

Still considering the workshop impact in teachers, once more, they valued the opportunity of practice change, particularly through the innovation of strategies.

Objective 2 – teachers' perceptions on the development of mobile learning strategies in their practice, after attending a teacher training on these issues

Figure 3 shows trainee teachers reported mobile devices use to promote their students' learning, with 33 mentioning they use it a few times and 10 never use it.

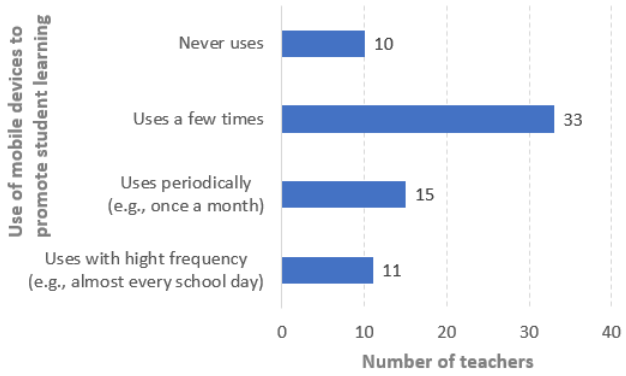

Figure 3. Teachers' use of mobile devices to promote student learning

Contrary to the expectations of the authors of this study, some teachers referred using mobile devices in their teaching periodically (15 teachers/21.7%) or with high frequency (11/15.9%). This could mean that teachers are starting to integrate mobile learning into their practices, as advocated by several Horizon Reports (Horizon Project Advisory Board, 2007; Johnson, Adams, Estrada, & Freeman, 2015; Johnson, Smith, Levine, & Haywood, 2010); however, this result should be interpreted with caution, as the literature reveals a different scenario regarding mobile devices adoption by teachers. For instance, in a survey with about a thousand teachers, O'Bannon and Thomas (2014) found statistically significant correlations between age, type of owned mobile phone, support for the use of mobile phones in the classroom, as well as perceptions of the benefits and barriers regarding their use in education. More specifically, they found that teachers over 50, similar to the cohorts of the five workshops analysed in this paper, are less likely to own smartphones, are less supportive of using mobile phones in the classroom, are less likely to acknowledge their usefulness in teaching and perceive their use in the classroom as more problematic.

The fact that these five cohorts of teachers are reporting a relatively high use of mobile devices in their teaching (a total of 20/35.7%) can also be due to the social desirability factor (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003), as teachers responses to this question may

be biased if this issue is perceived as a new cultural appropriated practice. This may be the case, as these results came from a questionnaire applied after a workshop related to technology integration in teacher practice.

When questioned about advantages of the use of mobile devices to promote learning, of a total of 69 teachers, 65 mentioned at least one advantage, with a total of 100 items (see Table 4). The identified advantages were diverse and were distributed into two categories:

a) 'teaching methodologies', with the sub-categories: 'gains for students', and 'gains for teaching practice'; and

b) 'technology under game-based learning contexts', with the sub-category 'mobile devices features'.

Table 4. Advantages of the use of mobile devices to promote learning, mentioned by the trainee teachers.

Category	Sub-category	Analysis dimension	Citations examples	Frequency
Teaching methodologies	Gains for students	Attention	'… students pay more attention.' Q3	7
		Motivation	'Students' motivation is higher.' Q50	44
		Engagement	'Students adhere more easily.' Q24	5
		Learning	'New way of learning…' Q3 'Promotion of their autonomy.' Q6 '…it facilitates learning.' Q19 '…to develop manual dexterity' Q55 'development of information and communication competencies' Q64	15
	Gains for teaching practices	Student-centred teaching strategies	'you can easily work teaching by discovery. Students search and learn with the guidance of the teacher, who becomes a mentor of teaching/learning' Q16	3
		Diversification of teaching practices	'it enriches and facilitates teaching practice' Q53 'to use a resource that is different from usual' Q59	2
		Supports evaluation	'it facilitates the collection of evaluation data' Q59	1
Technology under game-based learning contexts	Mobile devices feature	Usability	'with the use of attractive equipment' Q37 'Students can use a tool with which they identify themselves' Q2	2

Category	Sub-category	Analysis dimension	Citations examples	Frequency
		Resources availability	'Image collection and gathering of practical activities results.' Q25 'Possibility of use of different and innovative resources' Q37	4
		Enhances information access	'higher facility in access the information' Q23	11
		Supports interactivity and peer collaboration	'More interactivity' Q28 'Feedback is possible.' Q36 'Peer interaction' Q36	4
		Supports personalization	'Personalization' Q31	2
		Allows outdoor activities	'The lesson can be taught in the outdoors…' Q31	2
			Total	100
			No response -	4

Note: The notations 'Q' followed by a number indicate the questionnaire from which the citation example was taken

Students' motivation was clearly the advantage that gathered higher consensus, with 44 (63.8%) references in the questionnaires. Regarding student gains, learning had 15 (21.7%) references, usually without specifying what kind of learning, but sometimes mentioning aspects as new ways of learning, autonomy or manual dexterity. This last learning was mentioned by a special education needs teacher, suggesting, similarly to the literature (Passey & Zozimo, 2014), that mobile devices can support students with special needs. Other identified student related gains were increased attention and engagement, although with lower frequencies (7 and 5, respectively).

A few teaching practices gains were identified as well: student-centred teaching strategies (3 mentions); diversification of teaching practices (2 mentions) and supports assessment (1 mention). This last one is in line with the 'Assessment value' benefit mentioned by Passey and Zozimo (2014), where the mobile devices supports new ways for the students express themselves and expand the range of evaluation methods.

Finally, some mobile devices features were pointed as advantages, such as it enhances information access (with 11 mentions), resources availability (with 4) and supports interactivity and peer collaboration (also with 4). The related literature also mentions the information access as a key benefit of using handheld devices in education, particularly for the time saving factor (Passey & Zozimo, 2014). Other features were mentioned, with 2 mentions: the devices usability, personalization and allows outdoor activities.

From the above presented results, teachers acknowledge advantages in using mobile devices in education essentially for students, usually ignoring gains for their own teaching practices.

Alternatively, these results can be interpreted as these cohorts of teachers valuing more the gains for students than the gains for their own practices.

When questioned about constrains of the use of mobile devices to promote learning, 63 teachers mentioned at least one, with a total of 88 items (see Table 5). The identified constrains were also distributed into two categories:

a) 'teaching methodologies', with the sub-categories: 'Educational System related', 'teacher related', and 'student related'; and

b) 'technology under game-based learning contexts', with the sub-category 'technology related'.

Table 5. Constrains of the use of mobile devices to promote learning, mentioned by the trainee teachers.

Category	Sub-category	Analysis dimension	Citations examples	Frequency
Teaching methodologies	Educational System related	Curriculum accomplishment	'Difficulties in the accomplishment of the subject's curriculum.' Q32	1
	Teacher related	Teacher lack of confidence	'My difficulty in using those devices.' Q20	11
		Activities management	'Difficulty in managing the activities' Q33 'Difficulties in moving to other teaching activities, not involving mobile devices, afterwards.' Q55	4
	Student related	Distractions	'Distractions with other apps in the mobile devices.' Q5	9
		Lack of technology related skills	'Lack of technological skills of students' Q49	3
Technology under game-based learning contexts	Technology related	Lack of devices	'Lack of devices' Q8 'Lack of resources' Q11	25
		Lack of connectivity	'Lack of connectivity in the classroom' Q1	29
		Accessibility for special needs	'Lack of access for blind people.' Q46	1
		Visualization limitations	'For instance, we see only one page at a time of a	1

Category	Sub-category	Analysis dimension	Citations examples	Frequency
			sheet music' Q57	
			Total	88
			No constrains 'None' Q31	2
			No response -	4

Note: The notations 'Q' followed by a number indicate the questionnaire from which the citation example was taken

In what concerns mobile devices constrains, teachers focused on technology related issues, particularly the lack of connectivity either in schools and in other contexts (29 teachers pointed this issue) and of devices (25). Accessibility for special education needs and visualization limitations were also pointed by one teacher each. This last one, was also mentioned by Passey and Zozimo (2014), due to the small screen size of handheld devices. Other constrains were related with the education process participants: teacher lack of confidence in using those devices to promote learning (11 mentions) and in managing their classroom activities, particularly when moving from mobile learning to more traditional approaches (4 mentions); and student distractions with other mobile devices potentialities (9 mentions) and lack of technology related skills (3 mentions).

Considering the above, the main constrains for teachers in the use of mobile devices for teaching are still the lack of connectivity and of devices, revealing that more investment in these material and immaterial resources must be done in order to promote generalised use in education. This finding is in line with the literature, as Montrieux and colleagues (2015) highlights the relevance of the provision of learning material for mobile devices and an adequate IT infrastructure. Moreover, teacher lack of confidence in using these devices in education and in managing the activities can be tackled with more teacher training and other opportunities to implement mobile AR game-based approaches in their own practices, with support of specialists and of colleagues (Pombo, Carlos, et al., 2017).

From the above results, teachers seem to acknowledge both advantages and constrains in the use of mobile devices for learning, which is in line with Passey and Zozimo (2014). In our study, in absolute frequency, teachers identified more advantages than constrains. Hence, it can be claimed that, in spite of the difficulties foreseen, these experienced teachers may be initiating a process of incorporating mobile AR technologies in their teaching practices, although this last issue, needs further study, as discussed above.

Objective 3 – usability of the EduPARK app, according to the teachers

Teachers expressed their opinion about the EduPARK app tested during the workshop. Through the SUS (Brooke, 1996; Martins et al., 2015), which was computed accordingly to Brookes' instructions, they expressed their opinion regarding the app usability.

The EduPARK app reached an average of 78.7 in the SUS (Brooke, 1996; Martins et al., 2015), which corresponds to a good-excellent usability, according to Bangor and colleagues (2009). Additionally, according to this teacher cohorts, the app usability ranged from 47.5 (achieved in

threes questionnaires) to 100.0 (also attained in three questionnaires). As teachers adoption of mobile technologies seems to be positively related to their perception of their easiness of use (Prieto et al., 2015), an high SUS value, as the one reached by the EduPARK app, might reduce the resistance to practice change and, thus, contribute to the adoption of this app by educators in their practices.

CONCLUSIONS

This exploratory study aims to know teachers' opinions on mobile game-based learning with AR after teacher training on technology integration in practices. The case of the EduPARK workshop, which had five editions so far, was chosen to bring some light into this issue.

We bring empirical evidence regarding the opinions of a set of experienced teacher cohorts regarding their training needs: getting access to new educational resources, which was valued both immediately at the end of the workshop and after a month; having support in changing their teaching practices, which, likewise, was an issue that continued to remain in teachers minds a month after the workshop; updating their knowledge, although not necessarily in what concerns mobile learning, AR and game-based approaches; and learning about cross-subjects approaches to teaching. From the results, the EduPARK workshop was able to meet these needs, although more time to properly explore mobile AR game-based learning resources are needed if one intends to effectively support teachers in the changing of their practices.

After attending a workshop on mobile devices use in education, teachers are able to point both advantages and constrains, as advised by Pombo, Carlos, and Loureiro (2017). Some of the advantages were in line with the ones pointed in the literature, such as Passey and Zozimo (2014); however, new ones emerged in this study. Furthermore, teachers identified more advantages than constrains in the use of mobile devices in education and seem to being initiating the use of mobile devices in their own practices. However, this result needs to be studied further, to analyse if it is due to a social desirability factor. Regarding the advantages, teachers consider they are mainly for students, particularly their motivation, although acknowledging some unspecified learning gains. It was noteworthy that most teachers seem to ignore advantages of the use of mobile devices in education for their own teaching practices or these cohorts of teachers just value more the gains for students. Regarding the constrains, the lack of resources, mainly of connectivity and of mobile devices, is still the most present one in the teachers' minds, as referred in other studies (Pombo, Carlos, et al., 2017). Nevertheless, teachers reveal a lack of confidence in using these devices in education and in managing educational activities. This is a relevant issue that needs to be addressed, for example, by providing more teacher training and other opportunities to implement mobile AR game-based approaches in their practices, with support of specialists and of colleagues.

The EduPARK app can be a good starting point to promote mobile AR game-based learning, as this resource is open, free of charge and easy to use by teachers and their students.

Despite the teachers in the cohorts of these five EduPARK workshops reflect the demographics of the teaching profession in the Portuguese context, the results of this exploratory case study need to be interpreted with caution and within the scope of this study.

Further studies are needed with bigger and more diverse samples to better understand teachers' opinions on mobile game-based learning with AR after teacher training. Another limitation of this study is the use of a convenient rather than random sample. This is due to the need to the accessibility issues to the teachers' opinions and the mandatory requirement of teachers having attended training on technology integration on their practices. At last, the social desirability factor, as discussed before, may have impacted teachers' answers and have to be taken into consideration. Nevertheless, this study accomplished its purpose of eliciting teachers' opinions on mobile game-based learning with AR after teacher training.

Future work will be carried at two dimensions. Firstly, and regarding teaching training, the EduPARK workshop will consider the most relevant improvement suggestions presented by teachers, to better attend their needs. For example, future editions of the workshop can be organised in the Infante D. Pedro Park, e.g., *in loco*, and for a longer time period. Secondly, and in what concerns the mobile game-based learning with AR field of knowledge, future research should collect data with broader samples and should involve as well teachers' practices analysis, to triangulate teachers' opinions with their effective practices.

Acknowledgements

This work is financed by FEDER - Fundo Europeu de Desenvolvimento Regional funds through the COMPETE 2020 - Operational Programme for Competitiveness and Internationalisation (POCI), and by Portuguese funds through FCT - Fundação para a Ciência e a Tecnologia within the framework of the project POCI-01-0145-FEDER-016542.

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